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The purpose of this project was ro provide statistics and information gathered by Clemson Apparel Research on a study invesitgating the cost and benefits of Unit Production Systems in relation to the Progressive Bundle System which is the most common production control system used by US apparel plants.

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Short Term Task

Final Report

A STUDY OF THE COST AND BENEFITS OF A UNIT PRODUCTION SYSTEM VERSUS THE PROGRESSIVE BUNDLE SYSTEM

by

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1.0 *INTRODUCTION*

1.1 Overview and Project Explanation

Clemson Apparel Research, Clemson University, was funded in 1989 by the Defense Logistics Agency to complete a project comparing the manufacturing costs and productivity levels of United States apparel plants using Unit Production Systems (UPS) to those using a traditional Progressive Bundle Systems (PBS). Costs of operations on the bundle system were obtained by gathering historical data from two manufacturers that were currently producing (or had recently produced) the AG415 US Army military shirt. A comparative manufacturing cost per unit was calculated for both sites. The cost figures were for manufacturing costs only, and did not include costs for items such as fabric, buttons, trim items, marketing costs, freight and profit.

To obtain factual results from UPS operations, plant visits were made at eighteen locations that had installed UPS lines. Those eighteen UPS locations used 1299 workstations and employed 1069 direct labor operators. A survey was completed at each company to gather data in critical areas both before and after UPS installation. This information allowed for a direct comparison between the previous progressive bundle system operation and a UPS operation. (See Appendix I through Z for survey forms)

Before and after data was gathered in the following areas: Direct labor, Productivity, Excess costs, and Indirect labor. The resulting savings (or loss) in each area was then applied to the actual costs obtained from the two companies that were producing the AG415 US Army military shirt without UPS. This allows a projection of benefits that could be obtained on the military shirt if a UPS was installed. Data was also obtained in other areas that are normally considered intangible, such as quality, turnover, and attendance.

In addition, a substantial amount of other useful information was obtained from the survey of existing UPS sites such as: start-up cost, training cost, levels of operator participation, day to day operating philosophies, problems with UPS installations, installation costs, start-up problems, and recommendations from users.

1.2 History of Unit Production Systems

The concept of Unit Production Systems was developed in 1963 by Inge Davidson, who was then production manager and partner of the Eton Shirt

Company in Sweden. Mr. Davidson concluded that only about 20% of manufacturing costs are associated with actual sewing, while 80% of these costs represent material handling. With a goal of reducing this non-value-added time and increasing the relative share of value-added (stitching) time on the part of the operator, Mr. Davidson began searching the world in 1961 for such a system. Realizing that there was no such system on the market, Mr. Davidson committed two years of development to what became the first Unit Production System. Upon completion of the initial project, he realized that there were many more advantages than simple savings in handling time; there was a substantial reduction in through-put time, improvements in quality, turnover, attendance and space utilization. After several more years of development, the Unit Production System was introduced in 1968 to the worldwide apparel market. Today there are fourteen suppliers of Unit Production Systems representing seven countries worldwide. There are only three companies, however, currently serving the United States with fully automated systems (Eton Systems, The Gerber Mover, and INA Systems). In addition, Astechnologies sells a manual mover system. Over 60,000 operators are using Unit Production Systems worldwide today.

1.3 Definitions of Flexible Manufacturing Systems

1.31 The Unit Production System is basically an overhead conveyor which moves the single product between workstations. In addition to an easier pick-up and a free disposal at each workstation, the system addresses the time the garment is normally idle between workstations. Most importantly, Unit Production Systems address the weakness of imported goods: long delivery and customer response times. UPS requires a reduction in work in process levels and a change in the management philosophy of a sewn product plant from "high work in process is efficient" to "low work in process levels allow quick response". Unit Production Systems cause a reduction in direct labor content in that the equipment presents the garment directly to the operator for ease of pick-up and automatically removes the garment upon completion of the sewing cycle. Further, there is a complete elimination of bundle handling costs such as tying and untying bundles, pulling piecework tickets and completing clerical duties.

1.32 The Progressive Bundle System is the most common method of production flow control used in sewn products plants in the United States. Generally, it is a "batch" system in which small quantities, typically twenty to fifty units called a bundle, are processed in-tact through the plant. One operator will perform a single operation on all the pieces within the bundle before it is transferred to the next operator who will perform the next operation on all the pieces within the bundle. With high levels of work-in-

process (WIP), this system allows achievement of very high individual operator efficiencies, which is considered it's primary benefit. Typically, an individual incentive (piecework) operator compensation system is used. The disadvantages of the Progressive Bundle System include:

- High levels of WIP are required to achieve high operator efficiencies, therefore extending production lead times
- Operators are more interested in quantity rather than quality
- Operators are inclined to stay only on the operation on which they have the most experience, therefore limiting flexibility
- Customer responsiveness is limited due to the high WIP levels

1.33 A Flexible Work Group is a *management concept* involving a team of apparel associates with variations of the following characteristics:

- Continual training in problem solving techniques, brainstorming, effective communication, basic engineering, costing, scheduling, preventative maintenance, line balancing, ergonomics, conflict resolution, quality principles, safety principles, etc.

- Encouraged employee involvement; regular team meetings, authority to make all decisions involving the performance of the task

- Minimal supervision and service provided

- Production operators paid as a team rather than as individuals

- Encouraged cross training - highly flexible

- Responsible for total quality performance
- (cleaning, re-cutting)

- Maintaining very low work-in-process levels to achieve Quick Response and using the "pull" system of production flow control

- Equipment arranged so that work can be passed from one team member to the next

1.34 Flexible Manufacturing - "Any departure from traditional mass production systems of apparel toward faster, smaller, more flexible production units that depend upon the coordinated efforts of minimally supervised teams of workers." (AAMA, Technical Advisory Committee, 1988)

1.35 The "Push" System - This concept is normally used with "batch" systems in which bundles of work are moved from station to station. Each operator and operation "pushes" all available work forward without regard to work-in-process (WIP) levels at any point. The primary concern is maximizing efficiency at each workstation. This concept is well suited for the production piecework (individual incentive) compensation system because operators are normally provided large quantities of work to do in a given time allowing the development of high individual efficiencies. The disadvantage of the "push" system is that it tends to generate very high levels of work-in-process and often creates "bottlenecks" in the pipeline as some operations out-perform others. Prior to the implementation of Flexible Manufacturing concepts in the apparel industry, virtually all plants used the "push" system as the sole method of production control.

1.36 The "Pull" System - Each operator and operation performs work only if the subsequent operation in the manufacturing sequence needs a supply according to predetermined WIP levels. When work is not needed at a given operation, operators at the previous operation are idle or move to another operation on which work is needed to be done. The primary emphasis is on maintaining a given WIP level to achieve faster throughput times. This concept is not used effectively with "batch" systems, but normally is used with single or minimal unit production concepts. The number of units between operations may vary from zero to around ten. The piecework concept does not work well in this plan because operators are often required to change operations in order to affect the specified levels of work-in-process between operations. Also, there is occasionally a short period of waiting time prior to receiving or sending work to adjacent operations.

1.37 Hand-Off - Similar to a relay race, each production operator completes a task and passes that garment on to the next person in the production sequence. In the ultimate case, no product is ever idle, but is always being processed by one of the operators. Normally there is only one garment between operations. A Unit Production System can be considered a mechanized version of the hand-off system since the products are passed directly to the operator's work surface.

1.38 Kanban - Using a marked space at each workstation, operators are authorized to work only if the marked space at the subsequent workstation is empty. In some cases a ticket system is used rather than the marked space on the workstation. The applicable theory is that there is no need to provide more product for the subsequent operation than is needed at that time. This is an example of the Just-In-Time concept applied to the individual workstation. It is similar to the Hand Off concept except that some small

WIP levels are maintained between workstations to prevent stoppage of the entire line in the case of downtime at any workstation. A Unit Production System is a mechanized version of the Kanban system in that there is a specified queue between each workstation which is maintained by the computer control of the UPS. The tracking capability of the UPS serves as a control of the queue similar to the control of the tickets in the manual Kanban system.

2.0 *BACKGROUND* of AG 415 *MILITARY PLANTS*

Cost data was analyzed from two non-UPS manufacturers that were producing the AG415 US Army military shirt. Site 'A' produced 123,178 units of the AG415 shirt over a 35-week period. Site 'B' produced 237,982 units over 46-week period.

2.1 *Site 'A'* is a typical traditional manufacturer, producing both domestic and military apparel. The military shirt contract required about 20% of the productive capacity of the company. The company had produced the AG415 military shirt in past years as well as other military products. This plant was considered "low-tech" in that it had a very limited number of automated machines. The company did have an automated pocket setting machine, and had recently purchased a sonic fusing machine for collar stays. The company had approximately 150 operators in a 75,000 square foot building that housed cutting, sewing and distribution. Sewing operators were judged to be highly skilled and were working at an average pace.

2.2 *Site 'B'* is also a typical traditional manufacturer, producing both domestic and military apparel. The military shirt being produced required approximately 25% of the productive capacity of the company. The company had produced the AG415 military shirt in past years as well as other military products. The plant was considered "medium tech" in that some automated machinery was in use on a number of operations. The company uses automated equipment for pocket setting and collar making. Sewing operators were judged to be highly skilled and were working at an above average pace.

3.0 BACKGROUND of UPS PLANT VISITS

For purposes of comparison, visits were made to eighteen sites that were using Unit Production Systems. A detailed survey was completed for each site. It was the intent of this survey to obtain a representative sample of

companies using UPS, and the companies selected seemed to provide a good cross section of the industry.

Visits to these eighteen sites provided results in the following categories:

1. Diversity of product, including placket shirts, jeans, bedspreads, curtains, men's pants, military slacks, ladies' pants, ladies' blouses, bathrobes, children's tops and bottoms, skirts, men's dress shirts, pajamas and gowns.

2. Diversity of Vendors including Eton, Gerber, INA, Investronica, and Astechnologies. (Investronica is no longer a supplier of UPS in the United States)

3. Length of time on UPS ranging from five years to less than one year.

4. A substantial number of UPS stations (1299 stations with 1069 direct labor operators).

5. The companies surveyed represent a cross section of the apparel industry. The sites visited ranged from individually owned, single plant contract shops to plants owned by major U.S. apparel corporations. The utilization of UPS lines as a percentage of total plant capacity varied considerably from site to site, ranging from a low of 9% of total capacity to a high of 92%.

4.0 RESULTS FROM UPS SURVEYS

From the survey of eighteen sites using UPS, results were documented for all pertinent areas including standard costs, excess costs, productivity, indirect labor, quality, attendance and turnover. A straight average was used to determine results.

Following is a summary of the results obtained by UPS users as documented in the survey. This list includes only those results that are traditionally used to calculate payback for justification of capital expenditures such as Unit Production Systems.

4.01 Direct Labor (Standard Cost). Unit Production Systems led to a reduction in direct labor content of 9.7% by completely eliminating bundle

handling costs such as tying and untying bundles, the pulling of piecework tickets and the associated clerical duties. In addition, UPS presented the garment directly to the operator for ease of pick-up and then automatically removed the garment upon completion. Each of these elements is normally considered in calculating labor content for a production operation.

4.02 Operator Productivity. Operator productivity increased an average of 18.4%. This figure represents an actual increase of garments produced per hour for the entire plant versus the production levels achieved in a traditional bundle system for that plant. A portion of the productivity increase results from a reduction in direct labor content while the remainder is due to other somewhat unexpected benefits of UPS. One of those benefits, an unexpected advantage, is the requirement for better management of the work flow. Better planning and control normally translates into increased operator productivity over and above that gain which is attained through a direct labor content reduction. In addition, operators on UPS workstations normally develop much better methods than those using the traditional bundle system. The equipment provides a pace and rhythm for the operator which usually results in higher productivity. It is important to note here that the productivity improvements reflect improvements for the total manufacturing process, not just the operations directly using UPS. In the plants visited, approximately 38% of the sewing operators were on a UPS workstation. Improvements in productivity and other costs were measured only for those operations on UPS, but then translated to the remainder of the plant. Only 38% of the productivity increase measured for the UPS operators was applied to the whole plant. The applicable theory here is that productivity improvements are only worthwhile if the affect the entire productive capacity for the plant. In actuality, the companies surveyed achieved improvements throughout the entire manufacturing process because of the pace set by the UPS installation. The higher degree of management planning and control necessitated by UPS is probably the primary factor attributing to the productivity gain achieved on non-UPS operations.

4.03 Excess Cost (off-standard costs). Direct labor excesses were reduced by an average of 33.8%. Consequently, the UPS operations experienced less overtime, operator make-up and total repair costs versus those costs attributed to the previous progressive bundle system. In some cases, there was actually an increase in waiting time, job transfers, and machine delay caused by the drastic reduction of work-in-process. A machine problem at one workstation can quickly cause waiting time at succeeding workstations unless the machine is repaired quickly. In most companies, management had learned to react quickly to these kinds of problems. This quick-response attitude of management that developed in UPS installations is actually one

of the unexpected advantages of UPS. While there was in increase at some companies in waiting time, job transfer and machine delay, the increases were more than offset by reduction in overtime, operator make-up and repair costs.

4.04 Indirect Labor (supervision, service, quality, etc.). Indirect Labor was reduced by an average of one person per fifty-nine UPS operators. This translates into an indirect labor cost reduction of 11.8% within the plants visited. In a plant with minimal product mix and style change, a traditional bundle system supervisor can handle about fifty operators. Unit Production Systems vendors normally recommend about thirty-five operators per supervisor in a stable plant. A plant which has a high style mix may already have a smaller number of operators per supervisor and may experience a further reduction in overall indirect labor cost. It is to be expected that there will be a reduced service requirement since the work is automatically transferred between workstations by the system.

4.05 WIP (Work-In-Process). Work-In-Process levels were reduced by an average of 60.4%. This is a critical step toward Quick Response and has a direct relationship to throughput time. It also forces management discipline which is required to avoid production delays that will occur with low WIP levels. Regarding WIP levels and throughput times, the UPS user may select and control the queue at each workstation to achieve a given production lead time. No other Flexible Manufacturing System offers this feature.

4.06 Through-Put Time. Probably the most striking advantage of the Unit Production Systems is the drastic improvement in through-put time. Within the plants visited, the total cycle time was reduced from 14.9 days to an average of 5.9 days. The amount of throughput time reduction is fully controllable by the UPS user. If a shorter lead time is desired, the user only must reduce the queue at each workstation. It is important to note that this work-in-process reduction is an advantage only if these levels are reduced throughout the remainder of the plant and in the finished goods warehouse. Assuming that the UPS is installed only in the assembly area of the plant, work-in-process levels must also be correspondingly reduced in the cutting and in the parts manufacturing area. If a plant continues to operate with high work-in-process levels in these areas, then there is little advantage to be gained by reducing the work-in-process levels in the assembly area. Further, companies which produce to stock tend to negate the advantage of the UPS in that finished goods remain stored in a warehouse.

A UPS allows a plant to produce more to order and less to stock, thereby reducing total manufacturing costs. This advantage can be gained only if management discipline is forced throughout the organization.

It has been determined that the average through-put time for a woven shirt manufacturer ranges from four to six weeks from receipt of fabric to the availability to ship the finished product. With the proper application of management discipline throughout the operation, process time can be reduced to as little as five hours with the help of a Unit production System in the assembly area.

Faster through-put also results in accelerated invoicing since there is faster conversion of piece goods to finished product. This obviously improves the manufacturing cash flow.

4.07 Quality. The number of defects measured was reduced by 11.1% within the plants visited. This improvement is usually obtained because of the drastic reduction of work-in-process. Problems are not hidden in bundles and tend to show up quickly.

The effects of a team environment, however limited, also has a positive impact. This improvement in quality also directly affects operator productivity since more garments are sewn correctly the first time and less defects must be corrected. The reduction in defects results in a savings in the number of off-line repair people, mender carriers, etc. There is a better overall appearance of the products due to garments being hung versus tied in bundles and stored. These garments tend to require less inspection, cleaning and pressing. All of this results in a better quality product to the customer.

4.08 Operator Satisfaction and Morale. Production operators indicated an appreciation to work on a UPS line. The combination of a high-tech environment, the potential for increased earnings, and more of a team feeling seemed to contribute to higher morale. Because the distribution of work is accomplished, in most cases, by a computerized sorting system, all claims of "favoritism" are eliminated. Many of the computerized systems also offer semi-automatic line balancing because the supply of work is given to the faster operators automatically. The sorting of work can be accomplished automatically by size, style, and/or color, which results in a reduction in operator method changes and thread changes.

There also seems to be less fatigue, since operators do not have to pick up heavy bundles, and do not have to stretch to pick up and dispose of garments. The UPS also helps to pace operators by automatically positioning the next

garment. In addition, there is no bundle handling, which tends to break the operator's rhythm.

Other factors related to job satisfaction and morale resulted in the following improvements:

4.08.1 Production Operator Annual Labor Turnover. Operator annual turnover rates were reduced by 29.5%. From the survey, it is evident that UPS has a positive effect on labor turnover. In general, operators indicated a sense of pleasure in working on the UPS. Part of the appeal of UPS is probably psychological; i.e., a high-tech image enhanced by computers. Another factor impacting turnover is operator compensation. With UPS, operator earnings increased by 4.6%, or about $0.25 per hour.

Most companies did not use a team approach in their UPS units. For the most part, UPS operators were paid on individual incentive and compensation was slightly higher than operators in a progressive bundle system environment. From interviews with operators in UPS units, however, it was evident that informal teams had developed. There seemed to be higher levels of cohesiveness in the UPS units than in the PBS units. Since WIP levels are greatly reduced in UPS units, operators are considerably more dependent upon one another than in PBS units. It was evident that UPS operators felt an obligation to the group. The net effect was both a heightened sense of belonging and a feeling of importance, leading to increased job satisfaction and consequently a reduction in turnover.

4.08.2 Production Operator Attendance. Annual attendance rates were improved by 1.1%. It was surprising to learn that personnel statistics also improved as a result of a UPS installation. In addition to direct labor turnover improvements on the operations affected by the UPS installation, operator attendance improved from 94.6% to 95.7% on those same workstations.

Managers of UPS plants indicated that the operators who remained assigned to the bundle area within a plant were eager to transfer to the Unit Production System when a job became available. These managers also stated that turnover and attendance statistics were better within the UPS because operators were fearful that they would lose their jobs to others who were eager to transfer into the UPS.

Several plant managers even indicated that the quantity and quality of applicants improved after the community learned of the UPS installation,

and some applicants specifically asked to be assigned to the Unit Production System.

Given the fact that it is extremely difficult to attract and retain qualified employees in the apparel industry today, one of the major hidden advantages of a Unit Production System may be the improvement of these personnel statistics.

4.08.3 Workers' Compensation Claims. Although documented statistics were not available, most of the plants visited indicated a reduction in workers' compensation claims within the UPS installations. With UPS, operators are no longer required to pick up and move heavy bundles of work, eliminating a major source of back injuries. In addition, UPS presents the garment to the operator and also removes the garment upon completion, eliminating some of the most difficult motions that cause fatigue. While the repetitive nature of the operations may actually increase within the UPS since the system is doing some of the work allowing more units produced during the work day, there was no evidence of an increase in Repetitive Motion Disorders such as Carpal Tunnel Syndrome.

4.09 Operator Earnings (gross pay). Operator earnings increased by 8.7%, or approximately $0.25 per hour (productivity increase of 18.4% less direct labor cost reduction of 9.7%). About 56% of the plants visited also made adjustments to correct loose piece rates prior to the installation of UPS. The increase in operator earnings was achieved subsequent to these rate adjustments. The pacing provided by the system as the product is presented to each workstation is the primary reason for this increase in operator efficiency and earnings.

4.10 Floor Space Utilization On average, Unit Production Systems resulted in a reduction in floor space of 40.3%, from 110 square feet per work station to 78.4 square feet per work station. Most of this reduction is due to less storage space required for work-in-process. In a UPS unit, most of the work-in-process is stored on the system above the operator and machines are normally located closer together than machines in typical PBS units. In one company in the survey, a savings in floor space was the primary reason for choosing UPS. The company achieved a 50% savings in floor space and was able to considerably expand its product line without having to construct a new building.

4.11 Manufacturing Insurance Costs. These costs are often reduced because of the reduction in work-in-process levels. There is less inventory at risk of

fire or other damage, and sprinkler systems tend to operate better when the garments are hanging rather than tied in large bundles.

5.0 APPLICATION OF SURVEY RESULTS TO NON-UPS SITES

Standard costs were developed on the military shirt for the equipment presently being demonstrated at Clemson Apparel Research, and also for the UPS operation at CAR. From the standard operation bulletin, which is a listing of every production operation and its labor content, there are thirty-nine total operations, with eleven being performed on the UPS line. The total standard allowed minutes per shirt unit (SAM) is 13.3, which includes 5.0 SAM's per unit on UPS. Therefore, the total SAM's on UPS is 38% of the total.

These statistics are the basis to reasonably predict the effects on operating cost of introducing UPS into a company with a traditional progressive bundle system.

The average results obtained by the eighteen UPS sites was then applied to the actual operating data from the two non-UPS AG415 producing companies to determine the cost savings that should result by installing UPS on the military shirt.

The results show a net cost savings of producing the same product if a UPS system is used. The savings for site 'A' is $0.18 per unit, and for site 'B' is $0.22 per unit. Since only tangible savings are used, this is a "traditional" approach to calculating pay-back. See Appendix C and D.

6.0 APPAREL MANUFACTURING CAPITAL INVESTMENT ADVISOR

6.1 Description of AMCIA. The Apparel Manufacturing Capital Investment Advisor (AMCIA) is a microcomputer program designed to support capital investment decisions for new manufacturing technology in an apparel manufacturing plant. AMCIA was developed at Clemson Apparel Research through funding by the Defense Logistics Agency.

The objective of AMCIA is to help managers in the apparel industry reach a sound and logical decision regarding a proposed investment in new manufacturing technologies. A person involved in the investment decision making process might feel the need to purchase advanced technology in order to meet customer production or cost requirements, but might be unable to

translate this need into financial justification. AMCIA fills this need by providing a prudent and accurate analysis of the worthiness of a proposed investment.

6.2 Features of AMCIA:

- Uses a spread sheet environment with which many people are already familiar.

- Provides traditional pay back and return on investment analysis. Also uses the Net Present Value (NPV) concept, which accounts for risk and gives sound investment advice compared to other approaches. NPV combines the concepts of cash flow, the time value of money and risk and determines their relative value to the firm.

- Considers all the cash flows that are associated with a particular investment, including cash flows which are more uncertain. For cash flows which are considered risky, the program provides the user with the capability of selecting an appropriate discount rate pertaining to that cash flow and provides the risk-adjusted present value for that cash flow.

- Allows the user to easily incorporate additional miscellaneous cash flows that may be identified for a particular investment alternative.

- Provides sensitivity analysis which allows users to easily change parameters and see the corresponding result.

- Applicable to all apparel and other sewn products.

6.3 Description of *Net Present Value (NPV)* NPV is defined as the present value in dollars of all the cash flows that are expected to occur during the lifetime of the investment alternative. If the NPV is positive, the investment is advisable. NPV can be used to compare alternative investments: the one with the highest NPV is the most attractive.

NPV is the most technically sound approach of all commonly used investment justification systems, and it also provides a practical framework for considering risk. Having some way to account for riskiness enhances the quality of decision-making in two ways. First, it encourages the consideration of all cash flows associated with an investment, whether they affect cost or

revenues. Currently, managers often ignore cash flows which are relatively uncertain. Secondly, it allows the calculation of relative effect on each anticipated benefit. A factor such as direct labor savings will often be given a greater impact on the bottom line than a factor such as space utilization savings. This adjustment in impact is accomplished through use of the discount rate feature of AMCIA which will allow the user to indicate a level of certainty for each cash flow. The more certain a beneficial cash flow, the more it should be worth in the analysis of NPV.

6.4 AMCIA Analysis A justification analysis using the AMCIA model was calculated for the two non-UPS military contractors. This analysis considered both traditional and non-traditional factors as documented in the survey of seventeen UPS sites.

Manufacturing data, as originally gathered from the two military sites, covered a specific period of time on the production contract. For Site 'A', data was gathered for a 35 week period, and for Site 'B', data was gathered for a 46 week period. For the purpose of the justification analysis, all data was expanded to simulate a normal 49 week year. It was assumed that this additional production capacity would be filled with either a military or domestic product.

With the installation of UPS, increased efficiencies as documented in the survey would also increase production by 18.4% during the same period of time.

6.4.1 AMCIA Analysis - Site A. The survey of Site 'A' covered a 35 week period, which was the length of the military contract in that plant. An average of 40.5 operators per week worked on this contract. Assuming that 38% of the total product would be manufactured on the Unit Production System, 19 UPS stations would be required. The investment was based on this number of UPS workstations. In the final analysis, the UPS installation in Military Contractor Site A would generate a Net Present Value (NPV) of $159,900 on an investment of $95,000. The system is projected to achieve a payback in eleven months with a Return on Investment (ROI) of 328%. See Appendix C, D, and E..

6.4.2 AMCIA Analysis - Site B. The survey of Site 'B' covered a 46 week period, which was the length of the military contract in that plant. An average of 57.6 operators per week worked on this contract. Assuming that 38% of the total product would be manufactured on the Unit Production System, 27 UPS stations would be required. The investment was based on this number of UPS workstations. In the final analysis, the UPS installation

in Military Contractor Site B would generate a Net Present Value (NPV) of $299,600 on an investment of $135,000. The system is projected to achieve a payback in fifteen months with a Return on Investment (ROI) of 440%. See Appendix F, G, and H.

7.0 SURVEY STATISTICAL SUMMARY

The following statistics pertain to the eighteen site visits:

7.1 General Statistics.

Number of UPS stations - 1299
Number of UPS operators - 1069

Number of extra UPS stations (average) - 230 = 18%

Utilization of UPS work stations averaged 82%. Utilization varied from 50% to 100%.

The number of UPS work stations per site varied from a low of 20 stations to a high of 248 stations. Average work stations per site is 72 (1299 work stations/18 sites).

Number of spare machines = 17%

7.2 Percentage of Production Using UPS. The average application of UPS was 38% within all companies in the survey . Total production on UPS varied from a low of 16% to a high of 92%. Three companies could be considered 100% UPS, since automated and fast-cycled parts operations directly feed the assembly operations on UPS.

7.3 Service From Vendors. Of eighteen locations, thirteen companies reported excellent service from the vendors, two companies reported fair service, and three companies reported unsatisfactory service.

The primary reasons for giving an excellent rating on service were a vendor staff that was competent and willing to help, and an emergency service that was available day or night. Also rated high were those vendors that had the ability to go on-line with the customer's system for quick problem solving.

Those companies reporting unsatisfactory service listed the following reasons: generally poor or unresponsive service, an unwillingness of the vendor to modify software to solve particular problems, and an inadequate amount of pre-installation planning, especially with layout and training.

7.4 How Was Purchase Decision Was Determined? In every company surveyed, there was a distinct 'champion' that initiated the UPS decision. In the vast majority of companies, the champion was a senior management level person. It is also interesting to note that in three companies, the UPS champion had previously worked for another company that had used UPS.

In three of the companies, UPS was first learned of through an article in *Apparel Industry Magazine*. All companies visited at least one UPS installation before deciding to purchase. In two of these cases, a different vendor was recommended by the company visited. In other words, the plant personnel were sold on the UPS concept, but felt that another vendor was able to offer options that would be more beneficial.

Several of the companies researched the UPS concept for a year or more before making the investment decision. Only two companies, however, formally compared all domestic vendors.

7.5 UPS Goals Upon Installation. Companies were asked to list their three main goals for the UPS installation in order of importance. The following is a summary by goal:

Goal	# of Companies Listing as 1 of Top 3 Goals
Production Turn-time	12
Quality Improvement	5
Direct Labor Savings	5
Reduction of WIP	4
Productivity Increase	4
Innovation	2
Electronic Payroll/Lot Tracking	2
Savings in Floor Space	1
Indirect Labor Savings	1
Excess Cost Reduction	1
Cut Completion Improvement	1
Another Way to Re-engineer Plant	1
Means to Culture Change	1
High-tech as a Customer Sales Feature	1
Consistency of order completion	1

7.6 Were Loose Rates Adjusted? In about half of the companies surveyed, UPS presented the opportunity for companies to adjust 'loose', or out of line, piece rates. The overall adjustments were in the 5% to 10% range.

7.7 Management Organization. The Unit Production System requires a change in culture and standard procedure within the plant. The following were the changes reported by the companies in the survey.

7.7.1 What Changes Were Necessary? Most of the companies surveyed reported that UPS required more up-front planning and that management at all levels had to learn to react more quickly. In some companies the need to react quickly forced the scheduling function to be shifted from production control to the unit supervisor.

7.7.2 Overall Effect on Company Sales. About half of the companies reported that UPS had a definite impact on increasing sales of the company. The ability to turn goods quicker with improved quality were the major factors.

7.7.3 Are There Plans to Increase the Number of UPS Stations? Over one-third of the companies surveyed planned to increase the number of stations, either by adding additional lines, or by installing UPS at additional locations.

8.0 PRODUCTION AND COST RESULTS OF THE SURVEY

8.01 Flexibility. About one-half of the companies surveyed developed operators through cross-training. Some companies had intensive cross-training from the start of UPS. The end result is a flexible work force, capable of changing styles or product lines with few difficulties.

Most of the companies installing UPS chose, however, to continue with the previous operating philosophies used in the bundle system. Most operators had only one job assignment. In these companies, waiting time was abnormally high. It is increasingly common for UPS users to combine the philosophy of the Flexible Work Group (Modular) concept with the hardware of the UPS. This tends to combine the benefits of both systems and has a positive impact on the flexibility of the production operators.

8.02 Networking. Even though all three vendors offer the ability to network systems and plants together, only a few companies took advantage of these options. Some manufacturing companies had UPS software that is several years old that did not offer the option to network.

Current UPS software is available to allow a company to link several UPS lines together, and also to tie in to off-line operations. The software will accommodate multiple terminals in remote locations such as a terminal for the plant manager, engineer, etc.

8.03 Payroll Interface. Each UPS vendor has successfully networked gross payroll information from UPS to interface with the plant payroll package. This is seen as a requirement in order to maximize the use of the plant a accounting system.

8.04 Operating Philosophies. Relative to the production flow control systems, each UPS installation resulted in significant changes in standard operation philosophies.

8.04.1 Participation in Decision Making/Is a Team Approach Used? In the majority of companies, there were few changes in the levels of operator participation in decision making. A true team approach is becoming more popular and is seen as the most effective use of the UPS concept.

8.04.2 Cross Training. Procedures varied considerably, depending on the philosophy of management. Some companies chose not to do any operator cross-training, relying instead on utility operators to balance. Other companies selected a few key operators to cross-train on only a few critical operations. Other companies did extensive cross-training, insisting that all UPS operators learn at least two operations.

8.04.3 Operator Selection/Membership Changes. In most of the companies surveyed, UPS production accounted for less than 50% of total production. In all plants, UPS operators were generally selected from the regular bundle unit and, typically, operators were eager to move to the UPS. Of the companies where UPS accounted for the majority of production, new operators were trained on the UPS line. This procedure did, however, require extra UPS work stations.

8.04.4 Service Procedures. In most UPS lines, the need for service people was reduced. The system automatically moves the products to each workstation. In some cases the service person was actually a supervisor assistant, performing supervisory duties as well as distributing thread, quality repairs, cleaning and other like functions.

8.04.5 Quality and Repair Procedures. Most of the companies surveyed used an in-line inspection procedure, making use of roving inspectors and a statistical quality control (SQC) concept based on MIL STD 105E. Defects were tagged, recorded and returned back to the operator responsible through the computer-controlled system. Four of the companies did not use in-line inspection, and relied instead upon a final inspection audit after completion

of the final product. In the majority of companies, inspection procedures remained the same as used in the regular bundle unit.

8.04.6 Machine Repair Procedure. The majority of companies repaired machines within the UPS line. In most plants, priority is given to machines on UPS versus those in the PBS area of the plant. Most companies also had extra machines, either on-line or off-line, that could be moved into the UPS as necessary. Several companies had all machines on casters to facilitate the changing of machines when anticipated repair time was above a pre-set guideline, usually twenty minutes.

8.05 Pay Procedures. Of eighteen sites surveyed, seventeen sites used individual incentives (piece rates). Two of these companies used variable base rates. One company paid a team bonus as well as individual rates. This bonus was paid when the group performed better than the production goal for a specified time period. In addition, operators with less than perfect attendance for the week were ineligible to share in the group bonus.

One company used group incentives rather than individual piece rates. This company referred to this unit as a UPS module and operated it according to the standard Flexible Work Group philosophies. This team consisted of twenty production operators.

8.06 Start-Up. The procedure used for the initial start-up of the UPS varied significantly between companies in the survey.. The following questions provide insight into those philosophies.

8.06.1 Was Staff Member Assigned To Project? In the larger companies, a staff member, usually an engineer, was assigned to monitor and coordinate the UPS installation project. In the smaller companies, this task fell upon the plant manager. Overall, it was difficult to distinguish whether additional staff contributed to a more efficient UPS line.

8.06.2 Training for Operators/Management. All three vendors offer similar training plans for start-up of a UPS installation. Normally, a select group of managers and supervisors will spend one week training at the vendor's location. In addition, a test unit (typically five to ten work stations) is operated in the plant for two weeks to three months to help establish familiarity and to relieve operator fears. The vendor then would usually hold meetings with the production operators and the first line staff, accompanied by a film showing UPS in operation. Operators are then brought into the UPS unit in small groups. The vendor will normally spend at least one additional

week teaching proper methods to operators and teaching the supervisor and management how to balance the system.

8.06.3 Problems Encountered During Start-Up. Most users reported that the initial difficulty in using UPS is in learning how to balance the unit. To be successful, the supervisor must do more pre-planning and also must cross-train operators quickly. Significant operator resistance to change was noted in several companies. Resistance was especially strong in companies that chose to tighten loose piece rates which caused a reduction in operator earnings. This made it difficult for management to sell the UPS concept.

Several companies reported numerous problems with operators concerning the accuracy of payroll information. Since operators no longer had bundle coupons as records, there was a tendency to distrust the system. This was only a short term problem since the accuracy of the computer payroll system was later proven to be better than the manual ticket system.

In a number of companies, the line supervisor was not able to make the mental adjustments necessary to successfully manage UPS. It is clear that the UPS requires a higher level of management skill in order to operate the system successfully. Where additional training did not accomplish the necessary skill level, a personnel change was required.

8.06.4 Operators Lost Because of UPS. While the majority of companies experienced no loss of production operators as a result of the UPS installation, about 40% of the companies reported losing between one and five operators during or immediately after the installation. The probable causes of this loss in personnel was the reduction in production piece rates within some companies and the required change in production philosophy from the progressive bundle system.

8.07 Unit Operation.

8.07.1 Utility Operators/Line Balancing. Fifteen of the eighteen sites surveyed used utility operators to aid in balancing. The number of utility operators varied from one per one hundred operators to one utility per fifteen operators. About half of the companies used utility operators for the majority of balancing situations, preferring to keep UPS operators on a basic job. The other companies used utility operators sparingly, preferring instead to cross-train UPS operators on several jobs. Utility operators in those plants were used primarily to cover for absenteeism.

8.07.2 Layout of UPS. Arrangement of the unit varied considerably, depending upon the product being produced (size and complexity), the physical configuration of the building, and the number of UPS stations used as a percent of total production. Overall, all vendors offered flexible systems that could be customized to fit the needs of the plant.

In most companies, UPS is used only on the assembly operations. Small parts operations are prepared in a progressive bundle unit, often in a separate location. Two of the companies surveyed located the individual parts operations as close to the UPS stations as possible in order to minimize transfer distances (i.e., make and cut belt loops was located close to the tack loop operation in a men's slacks plant using UPS). This arrangement tended to link the small parts operators to the UPS line, thus forming one cohesive team. In these cases, the WIP levels of the small parts was much better controlled since the operators could see what parts were needed for various assembly operations. Also, there was a significantly better control of quality since the operators were in close proximity and could immediately communicate when problems did occur.

8.07.3 Work-In-Process on the Unit Production System. WIP varied considerably from plant to plant depending on a number of factors such as the number of operators on system, the type and complexity of the product, the number of trainees on system, the number of styles to be run at a given time, and the overall management philosophy of production flow control. In general, the queue was in the range of ten to twenty-five garments per work station. This queue level is completely adjustable per workstation within the system in order to create a shorter production lead time.

8.07.4 Modifications Needed. Few production equipment modifications were needed to successfully run a UPS line. A number of companies did cut down some machine tables in order to better position the UPS hanger to the machine, but this was not required. In addition, some companies put casters on all machines to aid in their transferring between workstations due to style changes or mechanical breakdowns.

Several companies purchased ergonomic chairs to aid the operators who constantly changed jobs within the UPS line. Two of the companies made use of wooden carrousels that accommodated two machines within one workstation. These carrousels were used when one operator was assigned to two fast cycle jobs and for flexibility where styles were constantly changing.

8.07.5 Use Of Computer Reports. All three vendors offer a wide array of standard management reports. These reports can be selected as needed in a

particular situation. In most cases, reports can be modified to suit the needs of the plant. From the survey it was found that most companies use only a limited number of the reports that are available. All three vendors offer a pre-planning program that is quite extensive and will aid in developing an efficient production plan for new styles.

8.08 Effect on Employee Morale. Most companies report that UPS did help them to attract a better quality applicant. UPS seemed to add a bit of prestige to the job. Operators stated that they viewed sewing within a UPS as a high technology assignment.

Overall, employees indicated a willingness to work within a UPS installation. The effects on employee morale can be measured by increased earnings, improved quality, less absenteeism and lower turnover. Operators also tended to feel that working on the UPS line was easier and caused less fatigue. The system was convenient to use since there were no bundles to handle and no piece work coupons to clip.

8.09 Other Benefits of UPS. Plant Managers indicated additional benefits of using UPS including:

- Fewer wrinkles in products and less pressing required
- UPS communicates a sense of permanence and stability since the community is aware of the capital investment of the company
- UPS helped to change the thinking about the benefits of lower WIP and faster through-put times
- UPS exposed other problems that existed and forced management discipline
- UPS helped keep track of garments and there was a minimum of lost garment parts

8.10 Current Problems with UPS. Plant managers indicated the following as typical problems that are yet to be solved in making the UPS installation as a complete success:

- Quality problems with pre-UPS operations are difficult to resolve because the part identity is lost if the production tickets are discarded.
- Some systems are unable to separate and track garment repairs from regular first quality production.

8.11 Recommendations From Users. The following were suggestions offered by current users of UPS regarding the most effective use of the systems:

- Sell operators on the benefits of UPS in advance of the installation
- When starting a new UPS line the plant must provide training for the supervisors to balance the system
- Never take hangers off system to create a balance. This will only prolong the problem and will negate the system's advantages.
- Plan a comprehensive training program for both managers and production operators
- Avoid the tendency to take out too much of the labor content which will cut the piece rates and reduce operator earnings. This is a certainty to create morale problems when operator cooperation is most critical
- Involve the mechanics and maintenance technicians from the start
- Do not try to install UPS initially throughout the plant. There is a need to draw from the bundle line for the initial production operators.
- Do not use utility operators for style changes. It is important to teach all operators to become flexible from the start of the UPS installation
- In a style shop, introduce a variety of styles in the beginning; do not try to protect the UPS operators from the inevitable operation changing
- Do a good job selling the concept to the production team indicating that the system will be a challenge, but will be rewarding to all
- Pay production operators on average while UPS piece rates are being developed
- If the UPS units are too large to develop a cohesive team, a group bonus or gain share compensation system is helpful to link individuals within the system
- Start using the computer system immediately so that management can maintain control and can learn the full benefits of the system
- Before deciding on a vendor, talk with and visit as many companies as possible that are presently using UPS
- Make sure stated features or claims by the vendors have been proven in the field
- Put all machines on casters to aid in machine repair and quick style changes

5.0 THE THEORY OF CONSTRAINTS AND SYNCHRONOUS MANUFACTURING APPLIED TO UPS

At least 90% of the North American apparel industry still uses the Progressive Bundle System (PBS) as the primary method of production flow control. This "batch" system coupled with the individual piecework system has generated very high work-in-process levels in most apparel plants. It is common to hear an apparel manager state that any time work-in-process levels become too low at a certain operation, the production operators slow down in order to make the time available equal the amount of work to be done. The advantage to the production operator in doing this is that she/he will be less likely be moved to another operation on which that person may have lesser skills. Obviously, the real motivation to stay on one job is the chance to make more money on the piecework system. All of this adds up to higher work-in-process inventories that are known to cause long production lead times. Since Quick Response is essential to the future success of the North American apparel industry and since low work-in-process levels are required to achieve Quick Response, it only follows that the progressive bundle and individual piecework systems must be changed to systems that will allow lower work-in-process levels and therefore faster throughput times.

To accomplish that objective, the rage of the North American apparel industry over the past ten years has been modular manufacturing (also called Flexible Work Groups) and Unit Production Systems. The basic difference between modular and the progressive bundle system is that modular requires a reduction in work-in-process levels across the board at every operation. While modular systems vary in design and operation between plants, the basic premise is that the work done by an individual operator is "passed off" to the next operator in the process. JIT and Kanban concepts were initiated to achieve this reduction in work-in-process levels. The UPS is actually a mechanized version of the modular concept in that the products are moved mechanically between workstations.

One of the major problems with these systems is that any time there is a disruption in the process (when Murphy makes an appearance) the entire production flow is stopped. Any apparel manager who has used modular manufacturing systems will attest to the fact that production will only continue for a few minutes after a machine goes down or after a production operator leaves his/her workstation. In order to avoid that problem, the plant invariably reverts back to the progressive bundle system mentality in which a higher work-in-process level is maintained between operations. This is, in essence, a protective buffer of work which will minimize the effects of Murphy.

The industry has learned that the greater this "buffer" between operations, the less impact any disruptions will have on total production.

The Synchronous Manufacturing philosophy takes a different approach to achieve Quick Response. It simply states that while inventory levels must be reduced, this reduction should occur strategically. Inventory of the right parts, in the right place, at the right time and in the right quantities is good. Inventory anywhere else is destructive.

Synchronous Manufacturing is defined as an all encompassing manufacturing management philosophy that includes a consistent set of principles, procedures and techniques where every action is evaluated in terms of the common global goal of the organization. This philosophy, often called the "Theory of Constraints" (TOC), was developed by Dr. Eli Goldratt author of The Goal. TOC is a very comprehensive management philosophy and includes a thinking process that analytically evaluates the entire manufacturing process to correctly determine the "core problem". This "core problem" can be defined as that issue which, if corrected, would have the greatest positive impact on the entire organization. Accurately identifying this "core problem" is one of the key elements of Synchronous Manufacturing/TOC and the thinking process is necessary in order to make a correct identification.

9.1 Drum, Buffer, Rope as a Method of Production Flow Control. The Synchronous Manufacturing philosophy also involves a set of logistical principles which challenge the standard thinking in the Apparel Industry. The production flow control concept, called *Drum-Buffer-Rope,* requires a drastic drop in work-in-process inventory and changes all the rules in regard to scheduling and production control. As a result, the way we measure plant effectiveness must also be revised.

The basis of the logistical system is that there are three possible major constraints effecting any manufacturing plant. Either the market is the constraint, in which the plant has a greater capacity than the market will buy, or the plants capacity is the constraint in that it cannot meet the market demands. The other possible constraint is the flow of raw materials from the vendors. In any of these cases, the product flow is "constrained" and maximum productivity and profits cannot be achieved.

Assuming the market is not the overall constraint, which is often the case in the apparel industry, and that the supply of raw materials is adequate, the plant is faced with the need to increase production. This usually means: work more overtime, hire more people and/or buy more equipment. Each of these solutions, if they are available at all, will cost significant amounts of money.

Synchronous Manufacturing suggests a new way to look at the manufacturing plant to achieve greater productivity and shorter production lead times. This philosophy is particularly adaptable to a Unit Production System installation.

9.2 Capacity Constraint Resources in UPS. Synchronous Manufacturing states that in any product manufacturing process (a chain of events), there is only one weakest link. There is only one operation or function which invariably causes bottlenecks and which, in fact, determines the plant's productive capacity. In other words, a plant can not ship more product than it can produce at its weakest operation. Accepting that fact suggests that we should schedule the entire manufacturing facility based upon the capacity of that resource. This function is then called the Capacity Constraint Resource (CCR).

A CCR is defined as any resource which, if not properly scheduled and managed, is likely to cause the actual flow of product through the plant to deviate from the planned product flow. There are four primary factors that should be considered in scheduling based upon the capacity of the CCR:

1. We should not plan production for the entire plant at the level any greater that the capacity of the CCR.

2. We should assure that the CCR is fully utilized. That machine(s) should be in full operation for the entire work day. If it is truly the constraint, then we can fully exploit its capabilities by assuring its operation even during breaks and lunch periods.

3. The schedule of product flow through the CCR should be based on the order in which the product is needed to meet customer delivery dates.

4. Every other operation is therefore a Non-Capacity Constraint Resource. By definition, these operations and functions have a greater capacity than the operation or function which has been defined as the CCR. Since they have a greater capacity than the CCR, that means that if they are allowed to produce at full strength all day long, there will be a build up of work-in-process inventory. Since this is not normally the objective, that means that these resources must be scheduled in such a way that they do not exceed the production of the CCR, or in other words, these Non-CCR's should be scheduled to the constraint's actual production; not to the level of their own capacity. Never should work be released to a non-CCR resource just to keep it busy.

In any manufacturing operation requiring a group of people to perform sequential functions, there are dependent events and statistical fluctuations. The law of dependent events states that when one operation or function feeds another, any variation in the performance of one will effect the ability of the other to perform. In other words, Operation B cannot continue to function unless it is supplied with the raw materials from Operation A. The sequential nature of apparel manufacturing is a good example of dependent events in a plant and can be electronically controlled through the functioning of the UPS.

The second phenomenon that occurs in all apparel plants is that of statistical fluctuations. It is obvious that individual operators will perform at a different pace on various operations. Couple that with absenteeism and occasional machine downtimes, and the calculated production capacity at any operation will always be more than the actual production. The problem is, we never know exactly when a machine will go down or when an operator will be absent. And it sometimes seems the operation which is most critical is the one that experiences the greatest number of problems.

The laws of dependent events and statistical fluctuations are minor in their effect on a single operation but become very serious as they are compounded through a chain of sequential operations. This is the reason that a production line of multiple operations never achieves its calculated capacity.

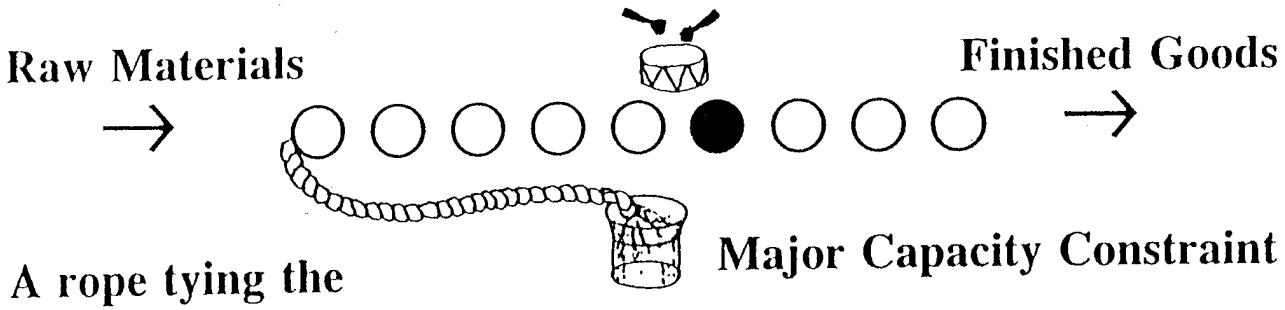
The concept of Synchronous Manufacturing recognizes that unpredictable downtimes will occur (Murphy exists) and develops a production flow control philosophy that deals with that fact. This concept is commonly known as "*Drum Buffer Rope*". See 9.1.

Having identified the constraint operation within a plant or department, this function is designated as the "*Drum*". Just as the drummer on a 17th century rowboat set the cadence by beating the drum, this operation determines the production capacity and the schedule for the entire plant. The operation must be "exploited" by assuring that it is fully operational at all times and that it is given first priority any time there is a machine malfunction.

Realizing that this operation determines the plant's productive capacity, a *buffer* of work-in-process inventory must be established prior to this operation to protect it from the expected disruptions at any previous operation in the plant. The level of this *buffer* will vary, but, as a rule of thumb, is not more than one half the productive capacity of the constraint operation within a work day. The level of the *buffer* is expected to fluctuate. As a downtime

situation occurs, some of the work in the buffer is used to protect the constraint.

The remainder of the plant should be scheduled based upon the productive capacity of the constraint. This is accomplished by extending a "*rope*" from the constraint operation back to the "gate" or feeding operation in that sequence. Rather than feeding raw materials into the process only at the rate at which any operation can consume it, this philosophy states that the raw materials should be fed only at the rate at which the constraint operation is producing. By doing this, we have established a methodology to keep the inventory levels low. This is easily accomplished in a UPS installation by programming the constraint ("Drum") operation to accommodate a certain buffer size of WIP. The "rope" is accomplished by allowing the system to feed only that which is produced at the constraint operation. A graphic illustration of DBR appears below:



The culture change required in most plants to operate "*Drum Buffer Rope*" has to do with realizing that by definition the non-constraint operations have a greater capacity and therefore will have some non-productive time during the workday. This is good. If this is not the case, the plant is "too balanced" and will not operate effectively using the "*Drum Buffer Rope*" method. In other words, the plant should be unbalanced with greater capacity at all operations except the designated CCR. Then the remainder of the plant can be properly scheduled and raw materials will be fed into the process based upon that schedule. If the plant is balanced, as is normally attempted in the apparel industry, the constraint will appear to move around during the day. Conversely, to properly operate *Drum Buffer Rope,* the plant must be un-balanced to the extent that the constraint is obvious and consistently located. Most importantly, an non-CCR should never be fed with work just to keep it busy. That does not increase throughput and only serves to add unneeded work-in-process inventory.

Another significant advantage of the "*Drum Buffer Rope*" philosophy, is that it minimizes the number of factors that must be constantly monitored by the production managers and supervisors. In a typical sewn products plant, managers are concerned about the efficiencies and production levels of every operation. Synchronous Manufacturing says that the only factors which are important are:

1. The production of the designated Capacity Constraint Resources.

2. The protective buffer levels serving those operations.

3. The rate at which raw materials are being fed based upon the production of the constraints.

9.3 Synchronous and UPS as a Method of Continual Improvement. Synchronous Manufacturing and the *Drum Buffer Rope* method of production flow control are also excellent methods of continual improvement. By focusing on the "core problem" in a plant, the system encourages a concentrated effort of all personnel on that single problem. When that "core problem" is solved or improved, a new "core problem" emerges and the process starts all over again. The concept is easily applied to the functioning of a Unit Production System. This is accomplished by using the five focusing steps of the Synchronous Manufacturing philosophy:

1. Identify the constraint. In any chain of events, there is only one weakest link. Once we have identified this weakest link, or constraint, we know the productive capacity of the entire chain.

2. Exploit the constraint. Having identified an operation or a function as the plant's constraint, we know that in order to increase the plant's productive capacity there must be an increase in the productivity of that constraint function. One way to do that is to make sure that the constraint operation or function is fully operational every minute of the work day including breaks and lunch periods and that it is given priority in every case of machinery malfunction. From a scheduling viewpoint, the constraint should always be working on the style/color/size that the customer needs.

3. Subordinate every other management decision to the above. Since the productive capacity of the CCR is defined as the productive capacity of the plant, every management decision throughout the corporation should be centered around maximizing the performance of that function. This certainly includes, but is not limited to, the production scheduling function, which must be based upon the capability of the CCR.

4. Elevate the constraint. Having accomplished the three steps above, the plant now is producing to its full capacity relative to its constraint. While overtime on that operation or function will help, the real solution to increased capacity is to add either people or machines to that function. By doing this, it is likely that operation will no longer be the plant's constraint.

5. If the steps above have caused the constraint to move, we should go back to step one and identify the new constraint. It is extremely important to note here, however, that procedural policies were probably created for good reasons when the previous constraint existed. Having changed that constraint, some or all of these procedural policies probably no longer apply. One of the greatest road blocks in any continual improvement process is the correct identification and elimination of those procedural policies that no longer have a purpose.

10.0 SUMMARY AND CONCLUSIONS

Flexible Manufacturing Systems will provide positive results to many of the problems facing the United States apparel industry today. The Summary of Results chart in Appendix A will indicate the expected improvement percentages of many measurable cost and production categories. Realizing that the niche for United States apparel manufacturers is in the ability to provide excellent quality and timely deliveries to the product, it is clear that Flexible Manufacturing Systems are viable.

Both Flexible Work Groups and Unit Production Systems will produce attractive results when compared to the Progressive Bundle System. The difference between the two systems is that in the Flexible Work Group concept the management style change is accomplished through training and implementation of employee empowerment principles. In the Unit Production System concept the management style changes are forced by the functioning of the system itself. It is clear then that the measurable improvements in production cycle caused by the Unit Production System, such as reduced labor content and automatic work distribution can be further enhanced by the incorporation of some Flexible Work Group concepts such as employee empowerment programs and group operator compensation plans.

Net productivity increases were 18.4% in Unit Production System and 13.4% in Flexible Work Groups. The reason for this difference is that the Unit Production System obviously creates reduced work content and automatic

movement of the work form station to station. In the Flexible Work Group concept, the production operators move themselves and must manually move the work from station to station.

Direct labor content is virtually equal in the Progressive Bundle System and in the Flexible Work Group. There is a minor reduction in direct labor content in a Flexible Work Group in that operator bundle handling and piecework ticket manipulation is eliminated, but additional time must be allowed then for the movement of the operators between work stations. Therefore, there is a "washout" of labor content value. In the Unit Production System concept, however, direct labor content is reduced significantly by 9.7%.

The team atmosphere typically created by the employee empowerment program of the Flexible Work Group concept provided an improvement in quality performance of 65.3% versus the 11.1% improvement indicated in the Unit Production System. By installing these employee empowerment programs in the Unit Production System, the full benefit of quality improvements may be realized. The other improvements of the two systems in direct labor excesses, indirect ratio, attendance and turnover statistics and space utilization were relatively equal.

It is the philosophy of the author that a Unit Production System is purely a mechanization of the Flexible Work Group concept. It follows then that the implementation of employee empowerment programs and other Flexible Work Group management philosophies within the hardware of the Unit Production System will achieve even better results. Several US apparel companies have begun to implement such a combination and have realized significantly better results than any reported in this study. These companies felt that the information was preliminary and that it was too early to report in this study.

Synchronous Manufacturing and the *Drum Buffer Rope* method of production flow control are well suited for the North American Apparel industry as we strive to become globally competitive. These procedures are particularly adaptable to installation within a Unit Production System. While the philosophy will challenge the standards of the industry, we must recognize that the current way of doing business has resulted in a loss of over 400,000 US apparel jobs in the last twenty years. A new way to compete must be identified to change that trend. Unit Production Systems are a step in the right direction, but the Synchronous Manufacturing approach will enhance that system and eliminate its shortcomings. The UPS installation at Clemson Apparel Research is operated using the Synchronous philosophy and "Drum, Buffer, Rope" is the method used for production flow control.

The successful apparel manufacturer in the United States must realize that competing on cost effectiveness alone is impossible. Therefore, in order to fully address the categories in which global competitiveness is possible, Flexible Manufacturing Systems must be employed. Both Unit Production Systems and Flexible Work Groups will help to achieve that competitive edge and the effective combination of the two with the production flow control concepts of Synchronous Manufacturing and the Theory of Constraints will provide the best results possible.

Appendix A
SUMMARY OF RESULTS

	PBS	FWG	% Improvement	UPS	% Improvement
Net Productivity			+13.4%		+18.4%
Direct Labor Content			-0.3%		-9.7%
Direct Labor Efficiency			+7.7%		+4.6%
Direct Labor Excesses	13.3%	5.7%	-57.1%	8.8%	-33.8%
Quality (% Defective)	7.2%	2.5%	-65.3%	6.4%	-11.1%
Through-put Time (Days)	14.9	4.3	-71.1%	5.9	-60.4%
Indirect Ratio			-10%		-11.8%
Attendance	94.6%	97.2%	+2.6%	95.6%	+1.1%
Turnover	50.9%	30.7%	-39.7%	35.9%	-29.5%
Space Utilization (Square Feet/Operator)	110 ft.	69.4 ft.	-36.9%	78.4 ft.	-40.3%
Sites Visited	30	12		18	
Number of Operators		2680		1069	
Number of Work Stations		3204		1299	
Number of Units (installations)		165		30	
Operators Per Unit		16.4		35.6	

Legend: **PBS = Progressive Bundle System**
FWG = Flexible Work Group
UPS = Unit Production System

UPS PLANT SURVEY

	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5	SITE 6
Survey	Crystal					
Number of UPS Stations	60	50	248	52	80	40
Supplier	Gerber	Eton	Eton	Eton	Gerber	Gerber
Number of UPS Lines	1	2	4	2	2	1
Total Workers	54	26	220	47	70	20
Products Sewn	Shirt	Shirt	Jeans	Bedspreads/Curtains	Shirts	Pants
Method of Pay	Individual Incentive	Individual Incentive	Individual Incentive	Individual Incentive	Individual Incentive	Group
Were Loose Rates Adjusted?	Yes	Yes	Yes	No	No	No
Direct Labor Savings(%)	8.60%	7.20%	11%	2%	8%	9%
Effect On Efficiency(%)	(+) 10 %	(+)12%	(+) 8%	(+) 5%	(+) 15%	(+) 14%
Excess Cost Savings(%)	16 to 2% (88%)	18 to 2.5% (86%)	20 to 16 (20%)	20 to 9 (55%)	30% to 25% (17%)	35 to 27 (23%)
Indirect Labor Savings (# People)	-1	-2	NA	-5	-2	-1
Work in Process Reduction (Days)	16 TO 11 (31%)	15 to 10 (33%)	13 to 5 (62%)	NA	4 to 1/2 (88%)	10 to 1 (90%)
Improvement In Quality (Defects)	7 TO 1 1/2 (79%)	6.5 to 1 (85%)	15% to 9% (40%)	NA	20 to 15% (25%)	15 to 5% (67%)
Improvement In Turnover Rate	45 TO 11 (75%)	60 to 20 (67%)	34% to 34% (0)	NA	50 to 25% (50%)	50 to 25 (50%)
Improvement In Absenteeism	8 TO 1 1/2% (81%)	6 to 1 (83%)	8% to 8% (0)	6 to 4 (33%)	6 to 6% (0)	6 to 2 (67%)
Space Reduction (sq. feet)	N/A	N/A	25%	50%	12%	N/A

UPS PLANT SURVEY

	SITE 7	SITE 8	SITE 9	SITE 10	SITE 11	SITE 12
Survey						
Number of UPS Stations	100	44	52	36	200	107
Supplier	Eton	INA	Eton/Investronica	Eton	Gerber	Gerber
Number of UPS Lines	1	1	2	1	3	2
Total Workers	100	26	30	25	143	92
Products Sewn	Military Slacks	Ladies Bottoms	Ladies Blouse	Bath robes	Childrens Knit Tops	Pajamas, Robes
Method of Pay	Individual Incentive	Individual Incentives	Individual/Team Bonus	Individual Incentive	Individual Incentive	Individual Incentive
Were Loose Rates Adjusted?	Yes	Yes	No	Yes	Yes	Yes
Direct Labor Savings(%)	9%	15%	10%	12%	10%	2 1/2%
Effect On Efficiency(%)	(+) 9%	(+) 12%	(+) 7%	(+) 43%	(+) 20%	(+) 10%
Excess Cost Savings(%)	10 to 16 (+ 60%)	30 to 26 13%	20 to 27+(35%)	N/A	0	0
Indirect Labor Savings (# People)	(+) 1	(+) 1	-1	-4	(-) 3 1/2	-4
Work in Process Reduction (Days)	15 to 9 (67%)	32 to 17 (47%)	30 to 20 (33%)	N/A	4 to 1 (75%)	30 to 10 (67%)
Improvement In Quality (Defects)	10 to 8 1/2 % (15%)	10%	9% to 5% (44%)	50%	12%	20%
Improvement In Turnover Rate	50 to 50 (0)	30 to 30 (0)	40% to 40% (0)	0	0	49 to 42 (15%)
Improvement In Absenteeism	3 to 3 (0)	10%	5% to 5% (0)	0	0	0
Space Reduction (sq. feet)	33	N/A	N/A	N/A	16%	25%

UPS PLANT SURVEY

	SITE 13	SITE 14	SITE 15	SITE 16	SITE 17	SITE 18
Survey						
Number of UPS Stations	92	44	20	24	24	26
Supplier	Gerber	INA	INA	Astech.	Astech.	Eton
Number of UPS Lines	2	1	1	1	2	1
Total Workers	92	40	17	24	20	23
Products Sewn	Dress Shirt	Robes/gowns	Skirts, Tops	Shirts	Tops, Bottoms	Robes
Method of Pay	Individual Incentive	Individual Incentive	Individual Incentive	Individual Incentive	Individual Incentive	Individual Incentive
Were Loose Rates Adjusted?	Yes	Yes	Yes	No	No	No
Direct Labor Savings(%)	15%	10.60%	10%	0	N/A	15%
Effect On Efficiency(%)	(+) 15%	(+) 15%	(+) 15%	(+) 8%	(+) 10%	19%
Excess Cost Savings(%)	12 to 9 (25%)	0	0	0	N/A	20 to 8% (60%)
Indirect Labor Savings (# People)	(+)5	(+)1	(+) 1/2	N/A	N/A	0
Work in Process Reduction (Days)	3.5 to 1/4 (83%)	15 to 5 (67%)	15 to 10 (33%)	6 to 1/2 (92%)	N/A	20 to 10 (50%)
Improvement In Quality (Defects)	0	0	0	0	N/A	10%
Improvement In Turnover Rate	0	0	0	-10%	N/A	5%
Improvement In Absenteeism	0	0	0	-10%	N/A	3.5 to 1.5% (57%)
Space Reduction (sq. feet)	N/A	N/A	N/A	N/A	N/A	40%

UPS PLANT SURVEY

Summary	Survey
1299	Number of UPS Stations
	Supplier
30	Number of UPS Lines
1069	Total Workers
	Products Sewn
	Method of Pay
	Were Loose Rates Adjusted?
-9.7%	Direct Labor Savings(%)
14.3%	Effect on Efficiency(%)
-33.8%	Excess Cost Savings(%)
-11.8%	Indirect Labor Savings (# People)
-60.4%	Work in Process Reduction (Days)
-11.1%	Improvement on Quality (Defects)
-29.5%	Improvement on Turnover Rate
1.1%	Improvement on Attendance
28.7%	Space Reduction (sq. feet)

SiteA.AMC

CLEMSON

CLEMSON UNIVERSITY

APPAREL MANUFACTURING CAPITAL INVESTMENT ADVISOR

Version 3.1
June, 1993

Clemson Apparel Research
Pendleton, SC 29670
803-646-8454

COMPANY DATA

Company name: SITE A

Project: Unit Production System

Number of annual working weeks: 49

Interest on the 3 month U.S. treasury bill: 5 %
(or another rate available for a safe
investment such as the yield of a
treasury bill maturing in about 6 years)

Company tax rate: 35 %

Fringe benefits as a percentage of payroll:

Direct Labor	25 %
Indirect Labor	25 %

Estimated average unit sale price of the product if you were to continue with current technology (dollars):

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
3.98	4.10	4.22	4.35	4.48	4.61

Estimated number of units to be produced if you were to continue with current technology:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
172449	172449	172449	172449	172449	172449

Estimated sales of the products affected by this decision if you were to continue with current technology (dollars):

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
686347	707041	727735	750153	772572	794990

Depreciation source: IRS 1988; MACRS after '86 (secs 167-168, 15,686-y).
Assets assumed to be acquired in year 0, with 5 year recovery period and half year convention.

Investment for the project (a negative number, in dollars):

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
-95000						

Original value of new equipment: 95000

Salvage value of new equipment: 23750

Retraining expenses (negative number): -9354

Installation expenses (negative number, in dollars):
(Include labor, machinery, consultation fees, transportation)

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
-15750						

Amount to be depreciated: 87000

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Depreciation rates:		0.2	0.32	0.192	0.1152	0.1152	0.0576
Depreciation expenses:		17400	27840	16704	10022	10022	5011
Depreciation tax savings:		6090	9744	5846	3508	3508	1754

Present value: 26632

Investment cash flows: -95000

Present value: -95000

Installation, retraining cash flows: -25104

Present value: -25104

DIRECT LABOR

	Present	Projected
S.A.M. (min/unit):	21.9500	21.1400
Base rate ($/min):	0.0833	0.0833
Direct labor efficiency (%):	87.0000	91.7000
Earned pay ($/unit):	2.1016	1.9204
Excess costs (% earned pay per unit): (Overtime, make-up, wait for work, machine delay, job transfers)	8.7000	8.0000
Total annual workers' comp. as a percentage of direct labor, not including fringe benefits.		
Cost ($/unit):	2.2845	2.0740

Implied change in annual production capacity (units):

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
15676	15676	15676	15676	15676	15676

Amount of the change in production capacity you wish to exploit:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
15676	15676	15676	15676	15676	15676

Summary of Direct Labor

Direct labor savings (in dollars):

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
4739	4739	4739	4739	4739	4739

Revenues due to exploited change in production capacity:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
62390	64272	66153	68191	70228	72266

After-tax equivalent of the above two cash flows:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
43634	44857	46080	47404	48729	50053

Confidence in this estimate (1-100): 80

Present value: 189263

INDIRECT LABOR

	Present	Projected
Indirect labor pay rate ($/hour):	6.30	6.30
Overtime costs as a percentage of the indirect labor pay rate:	2.600	2.600
Indirect labor costs ($/hour):	6.464	6.464
Annual indirect labor regular hours:	19104	18601

Summary of Indirect Labor

After-tax cash flows:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
2642	2642	2642	2642	2642	2642

Confidence in this estimate (1-100): 50

Present value: 6704

MAINTENANCE

Your estimate of maintenance expenses should include:
routine maintenance,
parts and supplies, and
service contracts.

Estimate of the change in total annual maintenance expenses:
NOTE: Negative numbers indicate reductions.

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	1045	1097	1152	1210	1270

Summary of Maintenance

After-tax cash flows:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	-679	-713	-749	-787	-826

Confidence in this estimate (1-100): 80

Present value: -3696

QUALITY RELATED COSTS

(Costs are positive numbers. Projected % Change is negative for a decrease in costs.)

	Present Cost	Projected % Change	Projected $ Change
Average annual labor cost of repair and reinspection for products affected by this decision:	$ 5834	11 %	648
Average annual cost of scrapped products:	$	%	
Annual net cost of seconds: (Include manufacturing costs minus revenues received for seconds.)	$	%	
Annual excess cost due to repaired, scrapped or second products: (This cost may include process delays or overtime to meet normal production, and should be in addition to overtime cost entered on the Indirect Labor Worksheet.)	$	%	

Summary of Quality Related Costs

After-tax cash flows:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
-421	-434	-446	-460	-474	-488

Confidence in this estimate (1-100): 50

Present value: -3440

INVENTORY

Your sales estimate with the current technology for the products affected by this decision is:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
686347	707041	727735	750153	772572	794990

Implied average throughput rate ($/week): 15098

Normal average inventory level (dollars): 72834

Implied throughput time (weeks): 4.82
If this seems unrealistic, adjust your sales estimates and/or your inventory estimate.

Expected % change in inventory level: -60
(Negative percentage indicates a decrease.)

Expected new throughput time (weeks): 1.91
If it seems unrealistic, adjust estimates before continuing.

Estimated change in inventory-related recurring cash flows, in dollars (e.g. warehouse rental charges, insurance, etc.):

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6

Summary of Inventory

After-tax cash flows:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
28595					

Confidence in this estimate (1-100): 80

Present value: 21786

MISCELLANEOUS

Flow #1 Name: **TURNOVER Rate Improvement** Confidence (1-100): **30** %

Estimated before-tax cash flows:

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
36120	36120	36120	36120	36120	36120	36120

After-tax cash flows:

23478	23478	23478	23478	23478	23478	23478

Present value of after-tax cash flows: **42794** dollars

Flow #2 Name: Confidence (1-100): **100** %

Estimated before-tax cash flows:

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6

After-tax cash flows:

Present value of after-tax cash flows: dollars

Flow #3 Name: Confidence (1-100): **100** %

Estimated before-tax cash flows:

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6

After-tax cash flows:

Present value of after-tax cash flows: dollars

Flow #4 Name: Confidence (1-100): **100** %

Estimated before-tax cash flows:

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6

After-tax cash flows:

Present value of after-tax cash flows: dollars

Flow #5 Name:

Confidence (1-100): 100 %

Estimated before-tax cash flows:

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6

After-tax cash flows:

Present value of after-tax cash flows: dollars

Total Miscellaneous after-tax cash flows (in dollars):

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
23478	23478	23478	23478	23478	23478	23478

Present value of total: 42794 dollars

SUMMARY TABLE

(Figures are in HUNDREDS of dollars)

Conf Fact	Present Value	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
TRADITIONAL FACTORS								
Investment:								
100	-950	-950						
Installation, retraining:								
100	-251	-251						
Depreciation:								
100	266		61	97	58	35	35	18
Old equipment sale:								
100								
Direct labor:								
80	1893		436	449	461	474	487	501
Indirect labor:								
50	67		26	26	26	26	26	26
Materials:								
100								
Maintenance:								
80	-37			-7	-7	-7	-8	-8
Quality costs:								
50	-34		-4	-4	-4	-5	-5	-5
Inventory:								
80	218		286					
Fabric utilization:								
100								
Miscellaneous:								
N/A	428	235	235	235	235	235	235	235
Total of traditional cash flows:		-966	1040	796	769	758	771	766

NON-TRADITIONAL FACTORS

Quality revenues:

100

Response-time revenues:

100

Total of non-traditional cash flows:

Total of all cash flows:

-966	1040	796	769	758	771	766

Net Present Value (NPV): $ 1599 hundred

Payback period: 11 months

Return On Investment (ROI): 328 %

Interpretation:

If NPV > 0, it represents how much better is this alternative than investing in "safe" U.S. Treasury bonds.

Payback period is how long it takes to "break even," ignoring the time value of money.

ROI indicates total return as a percentage of investment, ignoring the time value of money.

AMCIA DOCUMENTATION

SITE A

COMPANY DATA SHEET

1. Assumes 49 actual working weeks per year.

2. Interest on three month treasury bill assumed ot be 5%

3. Fringes - Total of 22.4% of Direct labor. (Includes: holidays, vacation, insurance, taxes, worker's compensation)

4. Unit Sales Price = $3.98 per unit which was the contract price on Cut, Make and Trim (CMT) only. Succedding years assumed a 3% price increase for inflation.

5. Actual contract production was 123,178 units over a 35 week period. Projected production on an annual basis of 49 working weeks was 172,449 units.

INVESTMENT, INSTALLATION AND DEPRECIATION WORKSHEET

Investment 19 UPS stations @ $5,000 x =	$95,000
Salvage Value @ 25% of the original cost =	$33,700
Retraining Expenses =	$9,354
Based on 10 week retrain curve	
Based on 16 operators	
Installation Expenses:	
UPS sites Visits to observe operations	$1,500
Site Preparation for UPS installation (Move machinery, new layout, move feedrail, steam, air, etc. and indirect overtime, etc.)	$14,250
Total Installation	$15,750

NUMBER OF WORK STATIONS REQUIRED

Based on 1989/90 Contract.

Number of Stations:

Base Rate = $5.00/hour x 87% efficiency = $4.35
x 40hr./wk. = $174.00
coupons earned/wk.

$174.00 earned/wk. less 6.2% absenteeism = $163.21

$163.21 earned/wk. less 8.7% excesses = $149.01

$149.01 x 31 weeks = $4,619
(35 weeks less 4 weeks sewing in and out)
average earned dollars per operator on contract.

Total coupons earned per contract $\frac{\$187120}{\$4619}$ = 40.5 operators

40.5 operators per week
x 38% UPS
15.4 UPS operators required
2.8 20% extra stations
18.2 UPS stations required
19 UPS Workstations used in Justification

Note: 38% of product manufactured on UPS is based on Clemson Operations Bulletin, assuming set collar through fold operation on UPS.

RETRAINING COST

Base Rate $4.54 per hour x 40 hour = $181.60 earnings/week at base

SUBSIDY WEEK OPERATOR	EXPECTED OPERATOR EFFICIENCY	SUBSIDY		WEEKLY PAY	COST OF PER
1.	66%	34%	x	$ 181.60	$ 61.74
2.	71%	29%	x	$ 181.60	$ 52.66
3.	76%	24%	x	$ 181.60	$ 43.58
4.	78%	22%	x	$ 181.60	$ 41.76
5.	82%	18%	x	$ 181.60	$ 32.68
6.	86%	14%	x	$ 181.60	$ 25.42
7.	90%	10%	x	$ 181.60	$ 18.16
8.	94%	6%	x	$ 181.60	$ 10.89
9.	97%	3%	x	$ 181.60	$ 5.44
10.	100%	0%			

$ 292.33
x16

$

4,677

++ overhead - 100% Total Retrain Cost/Oper.

4,677

$9,354

Note: Expected operator efficiency is based on a typical 10-week retrain curve.

AG415 MILITARY SHIRT

Operation Bulletin
SITE A

Parts Assembly	8 Hour SAM/pc
Sonic Stay	.1253
Fuse Collar	.1615
Collarstand	.2575
Run Collar	.2690
Turn & Topstitch Collar	.334
Run Epaulet (2)	.3041
Turn Epaulet (2)	.3423
Topstitch Epaulet (2)	.4380
Buttonhole Epaulet	.2062
Run Flap (2)	.2401
Turn Flap (2)	.3049
Topstitch Flap (2)	.3331
Serge Flap (2)	.1021
Buttonhole Flap (2)	.2107
Serge Pocket (2) & Stack	.0917
Attach Label	.2605
Set Pencil Pkt.	.4273
Set Patch Pkt. (2)	.4991
Press Front (2)	.5182
BH/BS Front	.5116
Set Flap (2)	.6652
BS Neck	.1365
Set Yoke	.3255
Hem Sleeves	.1719
Shoulder Join	.5602
SUBTOTAL W/O UPS	8.2771 = 62%

ASSEMBLY WITH U.P.S.

	SAM/pc
Load Eton	.1559
Set Collar	.6062
Close Collar	.4918
Buttonhole Neck	.1353
Baste Epaulet (2)	.2230
Buttonsew Epaulet (2)	.3082
Set Sleeve	.5599
Side Seam	.5984
Tack Sleeves	.1454
Bottom Hem	.4651
Unload Eton & Inspect	.6196
Fold	.7220
SUBTOTAL W/UPS	5.0308 =38%
TOTAL	13.3079

DIRECT LABOR WORKSHEET

SAM per unit = 21.95 reduced by 3.7% = 21.14 (9.7% observed x 38% UPS).

Base rate = $5.00/60 = $0.0833/min.

Efficiency = 87% actual on contract increased by 4.6% = 91.7% (14.3% observed x 38% UPS)

Excess Costs = 8.7% actual on contract reduced by 33.8% = 8.0% (19.5% observed x 38% UPS)

Workers' Compensation - No Change

Change in Annual Production Capacity fully exploited
Assumes additional capacity can be sold to civilian or military customers

Confidence level of certainty of 80% used

INDIRECT LABOR WORKSHEET

Indirect Labor Pay Rate = $6.30 per hour
Overtime (from production data) = 2.6%

Present Indirect Labor Hours =
9.5 people x 40 hours week x 2.6% overtime x 49 weeks/yr.
= 19,104 hours / yr.

Projected Indirect Labor Hours
average savings of 1.0 indirect labor persons
per site (for 64 workers) - 19 UPS workers / 64 x1.0 =
.25 Indirect Labor Persons Saved
= .25 person x 40 hour/wk x 2.6% overtime x 49 wks/yr
= 503 hours/yr savings
=19,104 hours - 503 hours
=18,601 hours.

Confidence level of certainty of 50% used

MAINTENANCE WORKSHEET

MAINTENANCE - Service contract - 0
Parts/year (Per Vendor) - $55/station
$55/station x 19 stations = $1045/yr.
(first year cost paid by the vendor)
(assumes a 5% increase per year)

Confidence level of certainty of 80% used

QUALITY RELATED COSTS WORKSHEET

Current Repair Costs = $4,167 FOR CONTRACT / 35 WEEKS
$4,167 / 35 X 49

=$5,834 Prorated annual repair cost.

$5,834 Annual Repair Cost
x 11.1% Improvement in number of defects from survey.
=$648 Yearly Savings in Repair Costs.

Confidence level of certainty of 80% used

INVENTORY WORKSHEET

THROUGHPUT RATE = $15098
Average over six years

INVENTORY LEVEL = 18,300 units x $3.98 = $72,834

% CHANGE IN INVENTORY = 61% decrease
(as documented from UPS survey)

Confidence level of certainty of 80% used

MISCELLANEOUS WORKSHEET

TURNOVER RATE-

From UPS survey - 29.5% Improvement
x 38% UPS
11.2% Improvement

Present Turnover Rate = 50%
Turnover = 150 operators x 50% = 75 Operators/yr.

Cost per trained operator =
$4300 x 75 operators lost/yr =
$322,500 cost/yr. x 11.2% improvement w/ UPS =
$36,120 savings/yr.

Confidence level of certainty of 30% used

	Actual Performance	% of earned $	With UPS	% of earned $	
Standard Labor (SAM)	21.95		21.40		SAM - Reduced by 3.7% (9.7% observed X 38% UPS)
Base Rate	5.00		5.00		Base Rate
Standard Cost (SAM x Base Rate)	$1.83		$1.76		Standard Cost - (Sam X Base rate)
Total Earned $	$187,120		$191,611		Total Earned $ - Increased by 2.4% (+4.6% efficiency,-1.7% excesses X 38% UPS)
Average Efficiency	87.0%		88.7%		Average Efficiency - Increased by 1.7% (4.6% observed X 38% UPS)
Direct Labor Excess					
A. Overtime	2,365	1.3%			
B. Make-up	5,874	3.1%			
C. Waiting for Work					
D. Machine Delay	2,100	1.1%			
E. Job Transfers	5,942	3.2%			
F. Repairs					
G. Other					
Total Sewing D. L. Excess $	$16,281	8.7%	$16,167	8.4%	D.L. Excesses - Reduced by 0.7% (8.7% actual X 19.5% reduction with UPS X 38% UPS)
Indirect Labor: (Sewing)					
A. Supervision	22,663	12.1%			
B. Service Assistance	6,368	3.4%			
C. Quality Control	6,300	3.4%			
D. P. G. Inspection					
E. Packing	10,746	5.7%			
F. Overtime	4,794	2.6%			
G. Other (Repairs)	4,167	2.2%			
Total Indirect Labor (Sewing)$	$55,038	29.4%	$53,463	27.9%	Total indirect labor - Reduced by 0.25 service person ($1,575 per year =$4.50/hr x 40 hour/wk x 35 wks.)(.25)
Total Cutting Labor	$17,441	9.3%	$17,820	9.3%	Total Cutting labor - as a fixed percent of earned dollars
Manufacturing Overhead					
A. Support Personnel	11,154	6.0%			
B. Depreciation	6,632	3.5%			
C. Interest Expense	19,103	10.2%			
D. Machine parts	6,984	3.7%			
E. Supplies	21,047	11.2%			
F. Taxes	530	0.3%			
G. Insurance	5,879	3.1%			
H. Utilities	10,246	5.5%			
I. Phone	935	0.5%			
J. Transportation	237	0.1%			
K. Management	38,105	20.4%			
L. Fringes	41,955	22.4%			
Total Manufacturing Overhead $	$162,807	87.0%	$162,514	84.8%	Total Overhead - Reduced by $293 (Fringes saved on 1 less Indirect)
Total Manufacturing Cost:	$438,687		$441,575		Total Mfg. Cost - Earned $ + Excesses + Indirect + Cutting + Overhead
Total Units Produced:	123,178		130,692		Total Units Produced - Increased by 6.1% (3.7% SAM +1.7% Efficiency 0.7% Excesses
TOTAL MANUFACTURING COST/UNIT	$3.56		$3.38		Total Manufacturing Cost / Unit

Savings = $.18 per unit

Actual

SiteB.AMC

CLEMSON UNIVERSITY

APPAREL MANUFACTURING CAPITAL INVESTMENT ADVISOR

Version 3.1
June, 1993

Clemson Apparel Research
Pendleton, SC 29670
803-646-8454

COMPANY DATA

Company name: Site B

Project: Unit Production System

Number of annual working weeks: 49

Interest on the 3 month U.S. treasury bill: 5 %
(or another rate available for a safe investment such as the yield of a treasury bill maturing in about 6 years)

Company tax rate: 35 %

Fringe benefits as a percentage of payroll:

Direct Labor	39 %
Indirect Labor	39 %

Estimated average unit sale price of the product if you were to continue with current technology (dollars):

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
3.98	4.10	4.22	4.35	4.48	4.61

Estimated number of units to be produced if you were to continue with current technology:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
253503	253503	253503	253503	253503	253503

Estimated sales of the products affected by this decision if you were to continue with current technology (dollars):

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
1008942	1039362	1069783	1102738	1135693	1168649

Depreciation source: IRS 1988; MACRS after '86 (secs 167-168, 15,686-y).
Assets assumed to be acquired in year 0, with 5 year recovery period and half year convention.

Investment for the project (a negative number, in dollars):

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
-135000						

Original value of new equipment: 135000

Salvage value of new equipment: 33750

Retraining expenses (negative number): -13448

Installation expenses (negative number, in dollars):
(Include labor, machinery, consultation fees, transportation)

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
-21750						

Amount to be depreciated: 123000

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Depreciation rates:		0.2	0.32	0.192	0.1152	0.1152	0.0576
Depreciation expenses:		24600	39360	23616	14170	14170	7085
Depreciation tax savings:		8610	13776	8266	4959	4959	2480
						Present value:	37652
Investment cash flows:	-135000						
						Present value:	-135000
Installation, retraining cash flows:	-35198						
						Present value:	-35198

DIRECT LABOR

	Present	Projected
S.A.M. (min/unit):	15.8200	15.2300
Base rate ($/min):	0.0865	0.0865
Direct labor efficiency (%):	88.0000	92.0000
Earned pay ($/unit):	1.5550	1.4320
Excess costs (% earned pay per unit):	16.6000	11.0000

(Overtime, make-up, wait for work, machine delay, job transfers)

Total annual workers' comp. as a percentage of direct labor, not including fringe benefits.

Cost ($/unit):	1.8132	1.5895

Implied change in annual production capacity (units):

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
33791	33791	33791	33791	33791	33791

Amount of the change in production capacity you wish to exploit:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
33791	33791	33791	33791	33791	33791

Summary of Direct Labor

Direct labor savings (in dollars):

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
4170	4170	4170	4170	4170	4170

Revenues due to exploited change in production capacity:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
134488	138543	142598	146991	151384	155777

After-tax equivalent of the above two cash flows:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
90128	92764	95399	98255	101110	103965

Confidence in this estimate (1-100): 80

Present value: 392017

INDIRECT LABOR

	Present	Projected
Indirect labor pay rate ($/hour):	6.30	6.30
Overtime costs as a percentage of the indirect labor pay rate:	2.600	2.600
Indirect labor costs ($/hour):	6.464	6.464
Annual indirect labor regular hours:	24735	24011

Summary of Indirect Labor

After-tax cash flows:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
4228	4228	4228	4228	4228	4228

Confidence in this estimate (1-100): 50

Present value: 10730

MAINTENANCE

Your estimate of maintenance expenses should include:
routine maintenance,
parts and supplies, and
service contracts.

Estimate of the change in total annual maintenance expenses:
NOTE: Negative numbers indicate reductions.

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	1485	1559	1637	1719	1805

Summary of Maintenance

After-tax cash flows:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	-965	-1013	-1064	-1117	-1173

Confidence in this estimate (1-100): 80

Present value: -5253

QUALITY RELATED COSTS

(Costs are positive numbers. Projected % Change is negative for a decrease in costs.)

	Present Cost	Projected % Change	Projected $ Change
Average annual labor cost of repair and reinspection for products affected by this decision:	$ 20461	11 %	2271
Average annual cost of scrapped products:	$	%	
Annual net cost of seconds: (Include manufacturing costs minus revenues received for seconds.)	$	%	
Annual excess cost due to repaired, scrapped or second products: (This cost may include process delays or overtime to meet normal production, and should be in addition to overtime cost entered on the Indirect Labor Worksheet.)	$	%	

Summary of Quality Related Costs

After-tax cash flows:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
-1476	-1521	-1565	-1614	-1662	-1710

Confidence in this estimate (1-100): 50

Present value: -12064

INVENTORY

Your sales estimate with the current technology for the products affected by this decision is:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
1008942	1039362	1069783	1102738	1135693	1168649

Implied average throughput rate ($/week): **22194**

Normal average inventory level (dollars): **72834**

Implied throughput time (weeks): **3.28**
If this seems unrealistic, adjust your sales estimates and/or your inventory estimate.

Expected % change in inventory level: **60**
(Negative percentage indicates a decrease.)

Expected new throughput time (weeks): **5.26**
If it seems unrealistic, adjust estimates before continuing.

Estimated change in inventory-related recurring cash flows, in dollars (e.g. warehouse rental charges, insurance, etc.):

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6

Summary of Inventory

After-tax cash flows:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
-28595					

Confidence in this estimate (1-100): **80**

Present value: **-32680**

MISCELLANEOUS

Flow #1 Name: **Annual Turnover Improvement** Confidence (1-100): **30** %

Estimated before-tax cash flows:

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	80186	80186	80186	80186	80186	80186

After-tax cash flows:

	52121	52121	52121	52121	52121	52121

Present value of after-tax cash flows: 79365 dollars

Flow #2 Name: Confidence (1-100): **100** %

Estimated before-tax cash flows:

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6

After-tax cash flows:

Present value of after-tax cash flows: dollars

Flow #3 Name: Confidence (1-100): **100** %

Estimated before-tax cash flows:

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6

After-tax cash flows:

Present value of after-tax cash flows: dollars

Flow #4 Name: Confidence (1-100): **100** %

Estimated before-tax cash flows:

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6

After-tax cash flows:

Present value of after-tax cash flows: dollars

Flow #5 Name:

Confidence (1-100): 100 %

Estimated before-tax cash flows:

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6

After-tax cash flows:

Present value of after-tax cash flows: dollars

Total Miscellaneous after-tax cash flows (in dollars):

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	52121	52121	52121	52121	52121	52121

Present value of total: 79365 dollars

SUMMARY TABLE

(Figures are in HUNDREDS of dollars)

Conf Fact	Present Value	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
TRADITIONAL FACTORS								
Investment:								
100	-1350	-1350						
Installation, retraining:								
100	-352	-352						
Depreciation:								
100	377		86	138	83	50	50	25
Old equipment sale:								
100								
Direct labor:								
80	3920		901	928	954	983	1011	1040
Indirect labor:								
50	107		42	42	42	42	42	42
Materials:								
100								
Maintenance:								
80	-53			-10	-10	-11	-11	-12
Quality costs:								
50	-121		-15	-15	-16	-16	-17	-17
Inventory:								
80	-327		-286					
Fabric utilization:								
100								
Miscellaneous:								
N/A	794		521	521	521	521	521	521
Total of traditional cash flows:		-1702	1250	1604	1574	1569	1596	1599

NON-TRADITIONAL FACTORS

Quality revenues:

100

Response-time revenues:

100

Total of non-traditional cash flows:

Total of all cash flows: -1702 1250 1604 1574 1569 1596 1599

Net Present Value (NPV):	$ 2996	hundred
Payback period:	15	months
Return On Investment (ROI):	440	%

Interpretation:

If NPV > 0, it represents how much better is this alternative than investing in "safe" U.S. Treasury bonds.

Payback period is how long it takes to "break even," ignoring the time value of money.

ROI indicates total return as a percentage of investment, ignoring the time value of money.

AMCIA DOCUMENTATION

SITE B

COMPANY DATA SHEET

1. Assumes 49 actual working weeks per year.

2. Interest on three month treasury bill assumed ot be 5%

3. Fringes - Total of 39.0% of Direct labor. (Includes: holidays, vacation, insurance, taxes, worker's compensation)

4. Unit Sales Price = $3.98 per unit which was the contract price on Cut, Make and Trim (CMT) only. Succedding years assumed a 3% price increase for inflation.

5. Actual contract production was 237,982 units over a 46 week period. Projected production on an annual basis of 49 working weeks was 253,503 units.

INVESTMENT, INSTALLATION AND DEPRECIATION WORKSHEET

Investment 27 UPS stations @ $5,000 x =	$135,000
Salvage Value @ 25% of the original cost =	$33,750
Retraining Expenses = Based on 10 week retrain curve Based on 23 operators	$13,488
Installation Expenses:	
UPS sites Visits to observe operations	$1,500
Site Preparation for UPS installation (Move machinery, new layout, move feedrail, steam, air, etc. and indirect overtime, etc.)	$20,250
Total Installation	$21,750

NUMBER OF WORK STATIONS REQUIRED

Based on 1989/90 Contract.

Number of Stations:

Base Rate = $4.54/hour x 88% efficiency = $4.00
x 40hr./wk. = $160.00
coupons earned/wk.

$160.00 earned/wk. less 4.0% absenteeism = $153.60

$153.60 earned/wk. less 16.6% excesses = $128.10

$128.10 x 40 weeks = $5,124
(46 weeks less 4 weeks sewing in and out and 2 weeks lack of work)
average earned dollars per operator on contract.

Total coupons earned per contract $\frac{\$304,241}{\$5124}$ = 59.4 operators

59.4 operators per week
x 38% UPS
22.5 UPS operators required
4.5 20% extra stations
27 UPS stations required
27 UPS Workstations used in Justification

Note: 38% of product manufactured on UPS is based on Clemson Operations Bulletin, assuming set collar through fold operation on UPS.

RETRAINING COST

Base Rate $4.54 per hour x 40 hour = $181.60 earnings/week at base

SUBSIDY WEEK OPERATOR	EXPECTED OPERATOR EFFICIENCY	SUBSIDY		WEEKLY PAY	COST OF PER
1.	66%	34%	x	$ 181.60	$ 61.74
2.	71%	29%	x	$ 181.60	$ 52.66
3.	76%	24%	x	$ 181.60	$ 43.58
4.	78%	22%	x	$ 181.60	$ 41.76
5.	82%	18%	x	$ 181.60	$ 32.68
6.	86%	14%	x	$ 181.60	$ 25.42
7.	90%	10%	x	$ 181.60	$ 18.16
8.	94%	6%	x	$ 181.60	$ 10.89
9.	97%	3%	x	$ 181.60	$ 5.44
10..	100%	0%			

$ 292.33
x23

$6.724

+ overhead @ 100% Total Retrain Cost/Oper. $6,724
$13,448

Note: Expected operator efficiency is based on a typical 10-week retrain curve.

AG415 MILITARY SHIRT

Operation Bulletin
SITE B

Parts Assembly	8 Hour SAM/pc
Sonic Stay	.1253
Fuse Collar	.1615
Collarstand	.2575
Run Collar	.2690
Turn & Topstitch Collar	.334
Run Epaulet (2)	.3041
Turn Epaulet (2)	.3423
Topstitch Epaulet (2)	.4380
Buttonhole Epaulet	.2062
Run Flap (2)	.2401
Turn Flap (2)	.3049
Topstitch Flap (2)	.3331
Serge Flap (2)	.1021
Buttonhole Flap (2)	.2107
Serge Pocket (2) & Stack	.0917
Attach Label	.2605
Set Pencil Pkt.	.4273
Set Patch Pkt. (2)	.4991
Press Front (2)	.5182
BH/BS Front	.5116
Set Flap (2)	.6652
BS Neck	.1365
Set Yoke	.3255
Hem Sleeves	.1719
Shoulder Join	.5602
SUBTOTAL W/O UPS	8.2771 = 62%

ASSEMBLY WITH U.P.S.

	SAM/pc
Load Eton	.1559
Set Collar	.6062
Close Collar	.4918
Buttonhole Neck	.1353
Baste Epaulet (2)	.2230
Buttonsew Epaulet (2)	.3082
Set Sleeve	.5599
Side Seam	.5984
Tack Sleeves	.1454
Bottom Hem	.4651
Unload Eton & Inspect	.6196
Fold	.7220
SUBTOTAL W/UPS	5.0308 =38%
TOTAL	13.3079

DIRECT LABOR WORKSHEET

SAM per unit = 15.82 reduced by 3.7% = 15.23(9.7% observed x 38% UPS).

Base rate = $5.19/60 = $0.0865/min.

Efficiency = 88% actual on contract increased by 4.6% = 92.0% (14.3% observed x 38% UPS)

Excess Costs = 16.6% actual on contract reduced by 33.8% = 11.0% (19.5% observed x 38% UPS)

Workers' Compensation - No Change

Change in Annual Production Capacity fully exploited
Assumes additional capacity can be sold to civilian or military customers

Confidence level of certainty of 80% used

INDIRECT LABOR WORKSHEET

Indirect Labor Pay Rate = $6.30 per hour

Overtime (from production data) = 2.6%

Present Indirect Labor Hours =
12.3 people x 40 hours week x 2.6% overtime x 49 weeks/yr.
= 24,735 hours / yr.

Projected Indirect Labor Hours
average savings of 1.0 indirect labor persons per site (for 64 workers) - 23 UPS workers / 64 x1.0 = .36 Indirect Labor Persons Saved
= .36 person x 40 hour/wk x 2.6% overtime x 49 wks/yr
= 724 hours/yr savings
=24,735 hours - 724 hours
=24,011 hours.

Confidence level of certainty of 50% used

MAINTENANCE WORKSHEET

MAINTENANCE - Service contract - 0
Parts/year (Per Vendor) - $55/station
$55/station x 27 stations = $1485/yr.
(first year cost paid by the vendor)
(assumes a 5% increase per year)

Confidence level of certainty of 80% used

QUALITY RELATED COSTS WORKSHEET

Current Repair Costs = $19,209 FOR CONTRACT / 46 WEEKS
$19,209 / 46 X 49

=$20,461 Prorated annual repair cost.

$20,461 Annual Repair Cost
x 11.1% Improvement in number of defects from survey.
=$2,271 Yearly Savings in Repair Costs.

Confidence level of certainty of 50% used

INVENTORY WORKSHEET

THROUGHPUT RATE = $22,194
Average over six years

INVENTORY LEVEL = 18,300 units x $3.98 = $72,834

% CHANGE IN INVENTORY = 61% decrease
(as documented from UPS survey)

Confidence level of certainty of 80% used

MISCELLANEOUS WORKSHEET

TURNOVER RATE-

From UPS survey - 29.5% Improvement
x 38% UPS
11.2% Improvement

Present Turnover Rate = 80%
Turnover = 210 operators x 80% = 168 Operators/yr.

Cost per trained operator =
$4300 x 168 operators lost/yr =
$722,400 cost/yr. x 11.2% improvement w/ UPS =
$80,186 savings/yr.

Confidence level of certainty of 30% used

UPS Comparison - Site B

	Actual Performance	% of earned $	With UPS	% of earned $	
Standard Labor (SAM)	15.82		15.25		SAM - Reduced by 3.7% (9.7% observed X 38% UPS)
Base Rate	5.19		5.19		Base Rate
Standard Cost (SAM x Base Rate)	$1.37		$1.32		Standard Cost - (Sam X Base rate)
Total Earned $	$347,747		$358,179		Total Earned $ - Increased by 3.0% (+4.6% efficiency,-3.2% excesses X 38% UPS)
Average Efficiency	88.0%		89.7%		Average Efficiency - Increased by 1.7% (4.6% observed X 38% UPS)
Direct Labor Excess					
A. Overtime	9,041	2.6%			
B. Make-up	32,688	9.4%			
C. Waiting for Work	1,391	0.4%			
D. Machine Delay	2,782	0.8%			
E. Job Transfers	0	0.0%			
F. Repairs	8,694	2.5%			
G. Other	3,130	0.9%			
Total Sewing D. L. Excess $	$57,726	16.6%	$55,160	15.4%	D.L. Excesses - Reduced by 1.2% (16.6% actual X 19.5 Reduction with UPS X 38% UPS)
Indirect Labor: (Sewing)					
A. Supervision	18083	5.2%			
B. Service Assistance	30,950	8.9%			
C. Quality Control	9,389	2.7%			
D. P. G. Inspection	3,477	1.0%			
E. Packing	11,128	3.2%			
F. Overtime	9,041	2.6%			
G. Other (Repairs)	13,214	3.8%			
Total Indirect Labor (Sewing)$	95,282	27.4%	$92,156	25.7%	Total indirect labor-Reduced by 0.36 service person ($3,126 per year =$4.72/hr x 40 hour/wk x 46 wks.)(.36)
Total Cutting Labor	$35,122	10.1%	$36,176	10.1%	Total Cutting labor - as a fixed percent of earned dollars
Manufacturing Overhead					
A. Support Personnel	73722	21.2%			
B. Depreciation	22,951	6.6%			
C. Interest Expense	0	0.0%			
D. Machine parts	12,519	3.6%			
E. Supplies	17,387	5.0%			
F. Taxes	695	0.2%			
G. Insurance	13,910	4.0%			
H. Utilities	21,212	6.1%			
I. Phone	3,825	1.1%			
J. Transportation	1,043	0.3%			
K. Management	85,893	24.7%			
L. Fringes	125,189	36.0%			
M. Other	12,171	36.0%			
Total Manufacturing Overhead $	390,517	112.3%	$389,298	108.7%	Total Overhead - Reduced by $1,219 (Fringes saved on 1 less Indirect)
Total Manufacturing Cost: 926,394	$926,394		$930,969		Total Mfg. Cost - Earned $ + Excesses + Indirect + Cutting + Overhead
Total Units Produced:	237,982		253,689		Total Units Produced - Increased by 6.6% (-3.7% SAM +1.7% Efficiency -1.2% Excesses
TOTAL MANUFACTURING COST/UNIT	$3.89		$3.57		Total Manufacturing Cost / Unit

Savings = $.22 per unit (5.7% reduction) x 237,982 units = $52,356 contract savings

NOTE: Actual figures from 1989 converted to 1991 dollars (14.3% increase)

Appendix H UPS Comparison Site B

UPS VENDORS

Fully computerized systems available in the United States:

ETON SYSTEMS
400 McGinnis Ferry Road
Alpheretta, GA 30201
Tel.: (404) 475-8022
Contact: Steve McLendon

COST: $5,000 - $7,000 per work station

GERBER GARMENT TECHNOLOGY INC.
24 Industrial Park Road West
Tolland, CT 06084
Tel: (203) Hal Osthus

COST: $4,000 - $6,000 per work station

INA SYSTEMS
Division of Irving N. Arnold Associates Ltd.
14 Ronso Drive
Rexdale, Ontario Canada M9W 1B2
Tel: (416) 248-6261
Contact: Irving Arnold

COST: $3,500 - $6,000 per workstation

Manual Movers Available in the United States:

ASTECHNOLOGIES
950 Sun Valley
Roswell, GA 30077
Tel: (404) 993-5100
Contact: Marty Pearson

COST: Approximately $1000 per work station

Fully computerized systems (not currently available in the United States)

INVESTRONICA S.A.
3216 Paces Ferry Place
Atlanta, GA 30305
Tel: (404) 261-8994
Contact: Peter Durkin - President (201) 348-0280

BROTHER INTERNATIONAL CORPORATION
8 Corporate Place
Pisentaway, NJ 08854
Tel: (201) 981-0300

MITSUBISHI
9000 Royal Lane
Irving, TX 75063
Tel: (214) 929-0046

Partially computerized movers (not currently available in the United States)

SINGER
4500 Singer Road
Murphreesboro, TN 37129
Tel: (615) 893-6493

JUKI AMERICA
5 Haul Road
Wayne, NJ
Tel: (201) 633-7200
Contact: Steve Kaufman

DURKOPP
3055-C Northwoods Circle
Norcross, GA 30071
Tel: 1-800-235-1075

Manual movers (not currently available in the United States)

KANSAI
170 Old Airport Road
Roebuck, SC 29376
Tel: (803) 576-0999

AMF
P.O. Box 15778
2100 Maples Shade Lane
Richmond, VA 23227
Tel: (804) 358-1165

YAMATO
P.O. Box 7226
8325-A Arrowridge Blvd.
Charlotte, NC 28273
Tel: (704) 523-7066

PROJECTED BENEFITS OF UNIT PRODUCTION SYSTEMS

IN US MILITARY APPAREL CONTRACTORS

Total expenditures in fiscal 1991 on military apparel: $1,100,000,000

Assumptions:

Fabric and Findings:		50.0%	$550,000,000	
Manufacturing:		50.0%	$550,000,000	
		Actual $	Improvement %	Projected $
Direct Labor (as a % of total manufacturing cost)	38.8%	$213,509,317	-18.4%	$174,223,603
(the following are a % of Direct Labor cost)				
Direct Fringe	22.0%	$46,972,050		$38,329,193
Indirect Labor	30.0%	$64,052,795	-11.8%	$56,494,565
Indirect Fringe	22.0%	$14,091,615		$12,428,804
Overhead	95.0%	$202,833,851		$165,512,422
Profit	4.0%	$8,540,373		$6,968,944

Total Projected Manufacturing Cost: $453,957,531

Total Projected Annual Savings $96,042,469